Forest Health Protection

Report 04-9 April 2004

MOUNTAIN PINE BEETLE, BLISTER RUST, AND THEIR INTERACTION ON WHITEBARK PINE AT TROUT LAKE AND FISHER PEAK IN NORTHERN IDAHO FROM 2001-2003

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INTRODUCTION

Whitebark pine stands in the Selkirk mountains have been steadily declining for many years due to a combination of white pine blister rust (*Cronartium ribicola)* (BR) and mountain pine beetle *(Dendroctonus ponderosae)* (MPB). BR has been present for many years causing a great deal of branch mortality and topkill in mature trees, and has greatly reduced survival and establishment of regeneration because small trees can be quickly girdled. BR has also contributed to mortality of large trees but over the past several years, mortality of mature trees has increased dramatically due to increasing populations of MPB. Ground surveys conducted in three areas of the Selkirks in the fall of 2000 documented a loss of 45%-82% of the whitebark pine primarily due to MPB (Kegley et al. 2001). In 2001, surveys in five additional areas found 17%-94% whitebark pine mortality primarily due to MPB (Kegley et al. 2004).

In 2001, Trout Lake and Fisher Peak areas had relatively low MPB populations and beetles appeared to prefer trees with severe BR infection (Kegley et al. 2004). We revisited those areas in August 2003 to determine if the status of MPB and its relationship with BR had changed.

METHODS

In August 2003, whitebark pine was examined for MPB attack and BR infection at Trout Lake and Fisher Peak on the Bonners Ferry Ranger District, Idaho Panhandle National Forests. Whitebark pine was examined in random strip surveys. Data recorded for each tree included diameter (d.b.h.) and a description of any bark beetle activity or blister rust infection.

Bark beetle activity was classified as current, last year, and older MPB attack, or unknown or secondary bark beetle mortality. Partial MPB bole attacks (strip attacks) and unsuccessful attacks (pitchouts) were also recorded. BR severity was classified as light for trees that had only dead branches or small branch cankers (red flags), moderate for trees with multiple large branch cankers or less than 30% top kill, and severe for trees with bole cankers or more than 30% top kill. BR rating of some trees was difficult because the crowns could not be seen clearly due to adjacent trees or crown fading

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from MPB attacks. It is unlikely they would have been severely infected, but since it was not possible to accurately determine the presence or absence of smaller cankers, these were placed in a separate category. Older dead whitebark pine (snags) were not recorded.

Four whitebark pines were felled at Fisher Peak to compare the amount of blister rust infection seen from the ground with what was actually present in the crowns. Once on the ground, every branch was closely examined for cankers, rodent chewing, and evidence of secondary bark beetles.

BR infection on regeneration was also tallied in random strip surveys in areas with whitebark pine regeneration. Sampled trees were at least 4 feet tall, so that they would have had sufficient exposure to infection, and less than 6 inches d.b.h. so they would be small enough to be considered regeneration. They were rated as not infected, infected or killed by blister rust and tallied in one inch diameter classes.

Logistic regression was used to explore the relationship between MPB attack, d.b.h. and BR condition. Pearson's chi square test was used to determine the probability of MPB attack on trees with different BR conditions. Data was then pooled to compare light and non-infected with those moderately and severely infected, and to compare severely infected trees with all others.

RESULTS

MPB populations increased at Fisher Peak and Trout Lake from 2001 to 2003 (Table 1). In 2001, 71% of the whitebark pine trees examined at Fisher Peak and 84% at Trout Lake were alive. In 2003, the amount of live whitebark pine decreased to 44% and 52%, respectively. Total dead from MPB attack increased at Fisher Peak from 27% in 2001 to 54% in 2003 and at Trout Lake from 14% to 44%.

Table 1. Whitebark pine with mountain pine beetle (MPB) or blister rust infection by area and year. Blister rust infection was determined from the ground with binoculars.

Location	Fisher Peak 2001	Fisher Peak 2003	Trout Lake 2001	Trout Lake 2003
# WBP examined	139	200	200	198
Ave. d.b.h.	14.2 in.	15.1 in.	16.9 in.	15.5 in.
WBP alive	99 (71%)	88 (44%)	167 (84%)	103 (52%)
Year 2003 MPB mass attack	na	42 (21%)	na	21 (11%)
Year 2002 MPB mass attack	na	36 (18%)	na	54 (27%)
Older MPB mass attack	na	30 (15%)	na	13 (7%)
MPB pitchout	na	1	na	0
MPB strip attack	na	3	na	6
Ave. d.b.h. with MPB	14.9	14.6	20.0	15.7
Ave. d.b.h. no MPB	13.9	15.8	16.4	15.4
Unknown or secondary beetle mortality	na	0	na	1
Total killed by MPB	37 (27%)	108 (54%)	28 (14%)	88 (44%)
WBP infected with Blister Rust	90 (65%)	133 (67%)	134 (67%)	143 (79%)

Average d.b.h. of trees attacked by MPB at Trout Lake was 15.7 inches compared with 15.4 inches for those not attacked. There was no significant relationship between tree d.b.h. and MPB attack at Trout Lake. At Fisher Peak, the average d.b.h. of trees attacked was 14.6 inches compared to 15.8 for trees not attacked. The probability of MPB attack at Fisher Peak increased with increasing d.b.h. up to 16.2 inches and then decreased as d.b.h. reached 25.2 inches. This made the average d.b.h. of trees attacked by MPB significantly smaller than those not attacked at Fisher Peak ($p<.03$). The opposite was found at both Trout Lake and Fisher Peak in 2001 when MPB populations were much smaller (Table 1). In 2001, MPB attacked significantly larger trees than those that were not attacked at five areas in the Selkirks with varying MPB populations ($p<.02$)(Kegley et al. 2004).

The proportion of trees with signs of BR infection in 2003 was slightly higher at Fisher Peak and 12 percent higher at Trout Lake (Table 1) than in 2001. Most trees sampled in 2003 at Trout Lake had light or moderate BR infections while most trees at Fisher Peak had light or none (Table 2.) Trees with severe BR infections were less than 15 percent at both sites, and the BR condition of 20 trees at Trout Lake and two at Fisher Peak could not be determined.

Table 2. Number and (percent) of BR infection levels observed at each area in 2001 and 2003. (Percents exclude trees with unknown BR.)

BR Cond Code	BR Infection Level	Fisher Peak 2003	Trout Lake 2003
0	No BR observed	63 (32%)	37 (20%)
1	Light infection	82 (42%)	57 (32%)
2	Moderate	30 (15%)	63 (35%)
3	Severe	21 (11%)	23 (13%)
	Total	*196*	*180*
4	Unknown	2	20

BLISTER RUST AND MOUNTAIN PINE BEETLE INTERACTIONS

When both areas were combined and all BR conditions were analyzed for MPB attack, BR condition 4 (couldn't see well enough to accurately rate BR) had over 90% successful MPB attacks which was significantly more than any other BR condition (none, light, moderate, or severe BR) (Table 3). Sixty percent of trees with no BR observed had successful MPB attacks which were significantly higher than the proportion of MPB attacks in trees with light or moderate BR infection. MPB attack success was also greater in trees rated clean than severely BR infected, but the difference was not statistically significant ($p=.11$).

Since the relationship of successful MPB attacks was so strong in the BR condition 4, it was felt that it might be clouding other relationships. Therefore additional analyses were made between all BR conditions except the condition 4 trees. When we pooled the light and non-infected trees and compared them to the moderate and severely infected trees, we found more successful attacks in the clean and lightly infected trees, but it was not statistically significant ($p=.07$) (Table 4).

Table 3. Number (percent) of trees attacked or not attacked by MPB by BR condition.

Blister rust condition (code)	Not Attacked	MPT Attacked	Unknown Mortality	Total
No BR observed (0)	4 (40%)	60 (60%)	0	100
Light BR (1)	73 (53%)	66 (48%)	0	139
Moderate BR (2)	54 (58%)	39 (42%)	0	93
Severe BR (3)	24 (55%)	20 (46%)	0	44
Could not accurately see (4)	1 (5%)	20 (91%)	1 (5%)	22
Total	192	205	1	398

Table 4. Percent of trees with none or light BR attacked or not attacked by MPB versus trees with moderate or severe BR.

BR condition	(codes)	Not Attacked	MPB Attacked
None or light	(0 or 1)	47%	53%
Moderate or Severe	(2 or 3)	57%	43%

When trees with severe BR were tested against none, light, or moderate BR conditions, a similar pattern was observed; MPB avoided attacking the most severely infected trees, but the difference was not statistically significant (Table 5). This may due to a small sample size of severely BR infected trees.

Table 5. Percent of trees with severe BR attacked or not attacked by MPB versus all other BR conditions.

BR condition	(codes)	Not Attacked	MPB Attacked
None, light or moderate	(0, 1, 2)	57%	43%
Severe	(3)	55%	46%

SAMPLING BLISTER RUST FROM THE GROUND VERSUS ACTUAL CROWN INFECTION

All four trees that were closely examined after falling had many small cankers that were not seen from the ground (Table 6). We did not see any cankers in two of the four trees from the ground even with careful inspection with binoculars. Typical flagging from BR infections on small branches was especially hard to see in trees that were fading due to MPB attacks. Very few cankers were actively sporulating, but most cankers could still be readily identified by characteristic branch swelling, discoloration, or resinosus (Figure 1). Most of the dead branches had cankers at the base and many had been chewed by rodents (Figure 2). A few branches girdled by BR also had galleries of small secondary bark beetles (*Pityophthorus* sp).

Figure 1. Small swollen branch indicative of BR infection.

Figure 2. Resinosus on rodent-chewed BR canker.

RUST INFECTION IN REGENERATION

About half of the regeneration tallied at both Trout Lake and Fisher Peak were infected with BR and about 5% were dead from BR (Table 7). Total infection percentage is much lower than the total infection observed in the mature trees nearby. The smallest regeneration trees had the lowest proportion of BR infection and the proportion of infected small trees tended to increase with diameter at both sites, but sample sizes of larger trees were quite small.

Table 6. Blister rust condition as seen from the ground with binoculars compared to actual cankers found in the crown of felled trees.

Tree#	BR condition from ground	# Cankers seen from ground	Actual # Cankers	MPB Condition
1	Severe (3)	3	11	2002 Attack (fading)
2	Moderate (2)	10	23	2003 Attack (green)
3	None (0)	0	20	2003 Attack (green)
4	None (0)	0	18	No attack

Table 7. Infection levels on a sample of regeneration.

	Fisher Peak			Trout Lake		
d.b.h.	Clean	Infected	Dead	Clean	Infected	Dead
<1	22	14	0	15	10	0
1	19	17	3	26	25	4
2	7	9	2	14	11	2
3	5	9	0	1	4	0
4	1	2	0	0	1	0
5	0	1	0	1	0	0
Total	54 (49%)	52 (47%)	5 (4%)	57 (50%)	51 (45%)	6 (5%)

DISCUSSION

In 2001, we found that MPB appeared to prefer trees infected with BR at relatively low beetle population levels at Fisher Peak (27% MPB-killed trees) and Trout Lake (14% MPB-killed trees). Two years later, MPB-caused tree mortality doubled at Fisher Peak, and more than tripled at Trout Lake and beetles appeared to prefer trees with little or no BR. These observations tend to support our earlier findings at four other areas that showed high MPB populations preferred trees with little or no BR (Kegley et al. 2003 and 2004). Therefore, there appears to be a point where increasing MPB populations switch from attacking BR weakened trees to apparently healthy trees. The high correlation between MPB attacks and trees that could not be clearly rated for BR (BR condition 4) was primarily due to the fact these trees were fading or older dead, which masked most blister rust infections, not because MPB actually preferred these trees.

Even though we have seen a significant relationship between MPB and tree diameter in other studies (Kegley et al. 2003 and 2004), we found no

relationship between MPB and d.b.h. at Trout Lake and a negative relationship at Fisher Peak in 2003. In 2001, the probability of MPB attack increased with increasing d.b.h. at these sites (Kegley et al. 2003). The apparent contradictory results on the relationship between MPB attack and d.b.h. between 2001 and 2003 is somewhat puzzling but is probably due to the few large diameter trees sampled. This relationship should be examined further.

Since different trees were measured during each year, the change in BR infection at Trout Lake may only reflect natural variation in the population of rust infected trees, rather than a real increase in infection level. We would not expect to see a large number of new cankers in just two years on mature trees. Even though the data indicates MPB attacked fewer severely infected trees, it was not statistically significant. But this may have been hampered by small sample sizes.

The inability to detect small cankers on trees from the ground is of real concern. Many surveys have taken data on “clean” trees, and this data is now highly suspect. This is also very important to those interested in selecting uncankered ‘plus’ trees for inclusion in a genetics program. Trees selected for breeding are climbed to collect cones, so are examined more closely for cankers at that time. However, some cankers near the tips of branches are likely to be missed even by climbers.

The amount of infection observed in the regeneration is similar to that seen in other places (unpublished data, Hadfield and Flanagan 1996). Regeneration trees, especially the smaller diameter classes, have not experienced as many (if any) periods of high BR infection, as well as being relatively small targets for rust spores. Therefore, it is not unusual to find infection increasing with tree size. It is also generally suspected that ribes plants in high elevations may be somewhat rare, or unlikely to become infected due to very narrow windows of proper weather conditions for infection. Therefore, infections may be due to spores traveling from distant sources (Schwandt and Guyon 1999, Goheen et al. 2000). If this is the case, it is also more likely that most infections would occur on the larger mature trees, simply because they are a bigger target and reach higher into the wind currents.

Although a few dead regeneration were tallied, it is also possible that very small trees may have an even higher rate of mortality, but were not tallied because they were less than four feet tall.

MPB activity will continue to be monitored in these high-elevation stands to provide mortality trends and additional information regarding possible relationships to BR infection. Additional trees should be felled to better determine the actual amount of BR in mature trees.

ACKNOWLEDGEMENTS

Gary Kempton and Ray Hoff assisted with the field surveys. Michael Marsden conducted the statistical analysis.

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